Society of Engineering Science 51st Annual Technical Meeting

1–3 October 2014

Purdue University, West Lafayette, Indiana, USA

Dynamic mechanical response and microstructural effects in commercially hot-pressed boron carbide under different loading rates and stress states

Farbaniec, Lukasz, lfarban1@jhu.edu; Shaeffer, Matthew; Ramesh, K T, Johns Hopkins University, United States

ABSTRACT

Boron carbide, with its high hardness and superior compressive strength, has become an attractive engineering material. Certain applications, notably ballistic protection, have drawn attention to its dynamic behavior. Like other brittle materials, the mechanical behavior of boron carbide is strongly related to the intrinsic microstructural flaws, e.g., non-metallic inclusions that form separate phases (graphite, BN, AlN) or voids. The critically sized and/or critically spaced flaws play important roles in dynamic failure processes as potential nucleation sites, and their relative importance depends on a combination of several mechanical properties. This study investigated the failure of a commercially hot-pressed boron carbide subjected to dynamic uniaxial and biaxial compression. The process was studied by loading small-size cubic specimens in a compression Kolsky Bar at strain-rates of ~10^3 s^{-1}. A high-speed camera was used to capture the failure process. SEM/EDS analysis was used to determine the chemical composition of the material matrix and flaws, and to identify critical actors in the failure process from the postmortem fragments. To study the strain-rate sensitivity, the mechanical behavior was also evaluated in the quasi-static regime (~10^{-3} s^{-1}) by using a servo-hydraulic testing machine in compression. The strain rate sensitivity for this material is typical of other advanced ceramics; the strength under dynamic compression was higher compared with the quasi-static strength. SEM/EDS examination showed that boron carbide has a microstructure with a complex superposition of inclusions of different composition and properties. It appears that the larger graphite-based inclusions are key factors contributing to the dynamic failure of this material.